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Aerojet-General CORPORATION

AZUSA, CALIFORNIA

INFORMAL REPORT OF PROGRESS

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TO: Commanding General
Frankford Arsenal
Philadelphia 37, Pennsylvania

Attn: ORDEA, Dr. H. Gisser

SUBJECT: Investigation of Stress-Corrosion Cracking of High-Strength Alloys

CONTRACT: DA-04-495-ORD-3069

PERIOD COVERED: 1 October through 31 October 1961

This is the eleventh in a series of informal progress reports submitted in partial fulfillment of the contract.

AEROJET-GENERAL CORPORATION

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NOTE: The information contained herein is regarded as preliminary and subject to further checking, verification, and analysis.

I. OBJECTIVES

The objectives of this program are

A. To study the susceptibility to stress-corrosion cracking of solid-rocket-motor case materials: e.g., Vascojet 1000, Type 300M, and Ladish D6AC steels, AM355 and PH 15-7 Mo stainless steels, and B120VCA titanium

B. To study the environmental parameters, including the atmosphere both inside and outside the rocket case, that affect the rate and extent of stress corrosion

C. To determine the effect of material parameters (composition, strength level, microstructure, surface conditions, etc.) on the stress-corrosion process

D. To devise and evaluate techniques for preventing the stress-corrosion cracking of solid-rocket-motor case materials.

II. WORK PROGRESS

A. BENT-BEAM SPECIMENS

All the environmental bent-beam stress-corrosion test data compiled to date are summarized in Table 1. These results reflect both completed tests and tests in progress. Six alloys are being evaluated in ten different environments. Specimens of Ladish D6AC, Type 300M, and Vascojet 1000 alloy steels, AM355 and PH 15-7 Mo stainless steels, and B120VCA titanium alloy were tested in air, distilled water, tap water, 0.25% sodium chloride solution, trichloroethylene, cosmoline, 4% soluble-oil solution, and high humidity.

No additional bent-beam testing has been initiated since the last report period. Welded test specimens of Ladish D6AC, Type 300M, and Vascojet 1000 alloy steels, and of B120VCA titanium are being prepared for bent-beam

stress-corrosion testing in tap water, distilled water, salt water, and high humidity - environments in which these alloys are most susceptible to stress corrosion. In addition, specimens of each alloy are being coated with solid propellant for environmental bent-beam stress-corrosion tests at ambient and at elevated temperatures.

B. U-BEND TEST SPECIMENS

All the environmental U-bend stress-corrosion test data compiled to date are summarized in Table 2. Three alloys are currently being tested in eight different environments. U-bend specimens of Ladish D6AC, Type 300M, and Vascojet 1000 alloy steels are being tested in distilled water, tap water, 0.25% sodium dichromate solution, 1% marquench salt solution, 3% sodium chloride solution, trichloroethylene, cosmoline, and 4% soluble-oil solution.

The test results reflect the cumulative effects of 140 days of testing. Failures were observed with each alloy in distilled water, tap water, salt water, and trichloroethylene. Whenever failure occurred, the comparative time-to-failure of the Vascojet 1000 specimens was the least, while that of the Ladish D6AC specimens was the greatest.

III. FUTURE WORK

The following future work is planned:

A. Continuation of the tests already in progress

B. Environmental stress-corrosion testing with welded bent-beam specimens of Ladish D6AC, Type 300M, and Vascojet 1000 alloy steels, and B120VCA titanium alloy in distilled water, tap water, salt water, and high humidity

C. Environmental stress-corrosion testing with bent-beam specimens of all the candidate alloys bonded with solid propellant at ambient and at elevated temperatures

D. Screening and evaluation of protective coatings for preventing or minimizing stress-corrosion cracking.

TABLE 1

BENT-BEAM STRESS-CORROSION TEST

Envir

Alloy	Yield Strength 0.2% Offset psi x 10^{-3}	Distilled Water		Tap Water		0.25% $Na_2Cr_2O_7$ Soln.		1% Marquench Salt Soln.		3% NaCl Soln.	
		No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)
Ladish D6AC	198.0	3	NF-21**	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	223.0	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	235.0	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
		6	NF-91	6	NF-91	3	NF-91	3	NF-91	3	NF-91
	252.0	3	NF-21								
		5	NF-91	3	NF-21	3	NF-21	3	NF-21	3	NF-21
		1	84.0	6	NF-91	3	NF-91	3	NF-91	3	NF-91
Type 300H	196.0	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	213.0	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	233.0	3	NF-21								
		2	NF-91	3	NF-21	3	NF-21	3	NF-21	3	NF-21
		1	84.0	3	NF-91						
Vascojet 1000	194.0	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	212.0	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	238.0	1	7.6	1	13.7					1	6.9
		1	7.8	1	14.7	3	NF-21	3	NF-21	1	10.0
		1	7.9	1	15.7					1	10.1
	242.0	1	1.8	1	2.7					1	1.2
		1	3.2	1	8.8	3	NF-21	3	NF-21	1	1.7
		1	4.3	1	9.7					1	6.7
AM355	199.0(T)***	3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	NF-49
	250.0(L)	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
		3	NF-91	3	NF-91						
	278.0(L)	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
		3	NF-91	3	NF-91						
PH 15-7 Mo	200.0	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96
	225.0	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96
	237.0	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96
B120VCA Titanium	138.0(L)	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
										1	NF-21
	140.0(T)	3	NF-21	3	NF-21	3	NF-21	3	NF-21	1	0.00+
										1	0.03
	146.0(T)	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	149.0(L)	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	158.0(L)	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
	166.0(T)	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-21
		3	NF-91	3	NF-91						

*Stressed to 75% of the 0.2%-offset yield strength.

**NF-21 = No failure in 21 days.

***L = Longitudinal, T = Transverse.

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TABLE 1

BENT-BEAM STRESS-CORROSION TEST DATA*

	3% NaCl Soln.		Trichloroethylene		Cosmoline		4% Soluble-Oil Soln.		Air		High Humidity	
...to ...ure ...ys)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	3	NF-155
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	1 1 1	NF-155 57.0 61.7
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	1 1 1	23.0 23.2 26.7
91	3	NF-91	3	NF-91	3	NF-91	3	NF-91	3	NF-91		
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	1 1 1	5.7 7.0 14.2
91	3	NF-91	3	NF-91	3	NF-91	3	NF-91	3	NF-91		
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	1 1 1	6.9 10.0 10.1	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	1 1 1	1.2 1.7 6.7	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
49	3	NF-49	3	NF-49	3	NF-49	3	NF-49	3	NF-49	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
96	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96
96	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96
96	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96	3	NF-96
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	1 1 1	NF-21 0.00+ 0.03	2 1	NF-21 3.4	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	2 1	NF-21 0.9	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-
21	3	NF-21	3	NF-21	3	NF-21	3	NF-21	3	NF-28	-	-

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TABLE 2

U-BEND STRESS-CORROSION

Alloy	Yield Strength 0.2% Offset psi x 10^{-3}	Distilled Water		Tap Water		0.25% $Na_2Cr_2O_7$ Soln.		1% Marqu Salt Sol
		No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens
Ladish D6AC	198.0	2	NF-140*	2	NF-140	2	NF-140	2
	223.0	1	NF-140	2	NF-140	2	NF-140	2
		1	137.3					
	235.0	1	20.2	1	NF-140	1	NF-140	2
		1	32.9	1	33.3			
	252.0	1	18.4	1	28.9			
		1	22.4	1	39.9	2	NF-140	1
Type 300M	196.0	2	NF-140	2	NF-140	2	NF-140	2
	213.0	1	18.4	2	NF-140	2	NF-140	2
		1	34.9					
	233.0	1	14.9	1	22.4	2	NF-140	2
		1	34.9	1	29.1			
Vascojet 1000	194.0	2	NF-140	2	NF-140	2	NF-140	2
	212.0	1	14.7	1	60.4	2	NF-140	2
		1	111.7	1	69.4			

*NF-140 = No failure in 140 days.

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TABLE 2

STRESS-CORROSION TEST DATA

oln. to ure ys)	1% Marquench Salt Soln.		3% NaCl Soln.		Trichloroethylene		Cosmoline		4% Soluble-Oil Soln.	
	Environment									
	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	No. of Specimens	Time to Failure (Days)	Specimens	Time to Failure (Days)
.40	2	NF-140	2	NF-140	2	NF-140	2	NF-140	2	NF-140
.40	2	NF-140	2	NF-140	2	NF-140	2	NF-140	2	NF-140
.40	2	NF-140	1 1	116.3 62.4	2	NF-140	2	NF-140	2	NF-140
140	1	NF-140	1	18.5	1 1	NF-140 46.9	2	NF-140	2	NF-140
140	2	NF-140	2	NF-140	2	NF-140	2	NF-140	2	NF-140
140	2	NF-140	1 1	11.3 40.9	1 1	49.9 56.1	2	NF-140	2	NF-140
140	2	NF-140	1 1	11.3 26.3	2	NF-140	2	NF-140	2	NF-140
140	2	NF-140	1 1	NF-140 49.9	2	NF-140	2	NF-140	2	NF-140
140	2	NF-140	1 1	4.3 6.8	1 1	46.9 46.9	2	NF-140	2	NF-140